THE PERIOD OF LIFE AT WHICH INFECTION FROM TUBERCULOSIS OCCURS MOST FREQUENTLY.

HOW MAY WE DIMINISH THE FREQUENCY OF THOSE INFECTIONS AND PREVENT THEM FROM BECOMING TUBERCULOUS DISEASE?*

WITH APPENDED NOTES ON A SUCCESSFUL ANTITUBERCULOSIS COMMUNITY EXPERIMENT IN AUSTRALIA AND A PROJECTED ONE IN AMERICA.

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This paper not only contains Doctor Knopf's own valuable conclusions upon the subject presented, but it is also a compendium of the opinions which Doctor Knopf has secured from a number of other eminent physicians.

FOR a soldier, whether in time of peace or war, whether fighting in defense of his country and obliged to kill or fighting an insidious enemy like tuberculosis and thus seeking to save life, the first duty is to obey. Even if in his own judgment the task assigned to him seems impossible, if his superior officer commands it he must do the best he can.

These were about the thoughts that came to my mind when my superior officer, Dr. W. S. Rankin, the Chairman of the Program Committee, assigned to me the above topic to present before the Public Health Officials' Section at this meeting. I asked myself, who knows anything about the period of life at which infection from tuberculosis occurs most frequently? I was sure I did not. My own statistics tell only of the occasionally recalled exposure to infection during adult life and of the cases of tuberculosis of either parent where there was a likelihood that infection had taken place some time during infancy or childhood, or even later, but at what exact age I had no way of knowing. In fact, I always thought that while it is possible to get statistical data of the period at which the tuberculous disease manifests itself, it is utterly impossible to determine the exact period of infection. But I was not going to be discouraged because of my own ignorance, and the fact that I did not know the period of life at which infection from tuberculosis

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occurs most frequently did not at all mean that others might not know a good deal about it. So in order to carry out the program, I determined to find out what information I could get on this subject.

I wrote forty letters to well-known specialists on tuberculosis and to internists who see a good deal of tuberculosis in their consultation practice, and twenty letters to well-known authorities on diseases of children.

I asked for the percentage of children infected with tuberculosis in general, at what age in particular, and what organs were most frequently involved. I then asked for the method of invasion and how often the infection could have been considered pre-natal. I then tried to ascertain at what period of life an infection, contracted in infancy or childhood, had the greatest likelihood to become active, and at what period of life in general tuberculosis had been found most frequently in the adolescents and the adults. Lastly, I asked my correspondents, in case no statistics were available, to favor me with their general impressions on the subject.

Many of my correspondents did not fail to impress upon me the difficulty of the task I had undertaken; some wrote encouragingly and some discouragingly, but all agreed on the great vital importance of such a study. Following are quotations from a few of the letters I received:

From our beloved Dr. E. L. Trudeau, the great scientist and scholar, friend and beloved physician, whose recent passing away deprived us of the greatest American authority on tuberculosis, but who, let us hope, has left with us his spirit, his enthusiasm, his devotion to the cause and inspiration to go on and on with the work, I received the following kindly note: "You must excuse me from answering the questions you are asking the rest of the profession. To be accurate it would involve an amount of work which I really don't think I can give to it. I hope the result of your inquiries will throw some light on this very obscure question."

Dr. Lawrason Brown, of Saranac Lake, said: "Really an inquiry such as your question would indicate would settle the whole matter and it seems to me almost impossible to determine the answer to question 6 (concerning mode of invasion). This would be largely guesswork, but if it could be based on scientific research would settle many vexed questions. I might say that I feel that the whole subject of etiology should be gone over again and some of us here are planning to do a little work in the matter."

Prof. S. Solis Cohen, of Philadelphia, said: "I shall be much interested in the result of your studies, and especially in your conclusions from your own statistics, which to me would be of vastly more importance than the guesses of all the rest of us put together." (I wish the good doctor would be half right in this assertion.)

Prof. Theodore C. Janeway, of Johns Hopkins, wrote me from his summer home: "The problem you have taken up seems to me one of the most fundamental for our understanding of the mode of infection in tuberculosis and for the selection of effective measures

of prevention. Exact statistics from a large number of sources on each of the points you raise will be of great help towards its solution. I wish I might contribute some, but I am entirely out of reach of my data, which are in Baltimore. I am most anxious for light on this problem and shall await the results of your study with great interest."

Prof. William P. Lucas, of San Francisco, makes the following significant statement: "I should be very glad to see your report lead to some immediate and definite attempt to really take up the subject from a statistical and scientific standpoint on a large scale throughout this country including all the children's hospitals in at least the university centers."

Dr. David R. Lyman, of the Gaylord Farm Sanatorium, wrote me: "I greatly regret that it is impossible for me to find time to go through my records for the data for which you ask. I recognize the great importance of the question and the need for its presentation and discussion."

Prof. John L. Morse, of Boston, writes: "It seems to me that in general a great many statements are made regarding tuberculosis in infancy and childhood on an insufficient basis. It seems to me, moreover, that a great deal of the discusson which is now going on about tuberculosis in childhood is in relation to entirely unimportant points and that there is danger of overlooking or neglecting the few important points."

Dr. Joseph E. Winters, Professor of Clinical Medicine, New York, writes: "My experience at Cornell and elsewhere convinces me that the diagnosis of tuberculosis in children is at present too hastily made and on insufficient evidence. Tuberculosis in childhood is not a latent disease as in adults. With the exception of glandular tuberculosis, it is an active and rapidly progressive disease. Its symptoms and signs are distinct, clear, and unmistakable. Would that I had the time to devote to the subject which it merits."

My good friend, Dr. Charles L. Minor, of Asheville, N. C., does not think a lifetime enough to go over his statistics, and this is what he says concerning them: "I have a vast amount of carefully kept histories, but I have no time to get up statistics out of them, and I expect I will be dead before that opportunity offers. In fact, I think we could have a very nice time in heaven going over and catching up with the work we had begun on earth." May Doctor Minor be spared a long time to continue his work on this earthly sphere, but when the time does come for him to pass to his heavenly abode and reward, I hope he may find more pleasant work to do in the other world, unless of course he should find working on tuberculosis statistics the most congenial heavenly occupation.

I must quote from another letter received a few months ago, not amusing and cheerful like the foregoing but, on the contrary, deeply sad and depressing, coming from the war zone where they are trying to do the very reverse of that for which we are assembled here. While we are bending all our energies to save life, prevent

untimely death and to further human happiness and peace, in Europe at this very moment they are sacrificing the best and most virile youths of the nations, killing and maiming thousands and sowing the seed of hatred and enmity among the nations. This must have been the thought of the Regius Professor of Oxford, Sir William Osler, when he wrote to me. This great man, though far removed from us, still takes the keenest interest in the work of his American pupils and friends. After giving me most valuable bibliographical indications, he says: "I am afraid I would not have time to look over my material and answer those questions intelligently. We are all working hard here. It is an awful business. One of the worst features is that it will dig an intellectual gulf between Germany and this country for generations. Let me have the results of your studies." May the great doctor's prophesy not come true and an early and lasting peace again unite the nations.

Professor A. Jacobi, that grand old man, eighty-five years young, sent me from his summer home a five-page letter, closely written in his own hand, giving me a wealth of information. At the end of this remarkable document full of bibliographical references and narrations from his own vast experience, he modestly says: "I am sorry I cannot contribute anything to your work, being in the country and having nothing in this desert that will add to your riches." Of course the good doctor refers to the riches of information I was supposed to have gathered from other sources since I have confessed to having none of my own.

Many other letters began with the usual regret not to be able to answer all my questions or some of them, or even any at all, because of lack of statistics, but from what follows you will see that a goodly number of my correspondents have most kindly aided me by letting me have whatever statistics they had or giving me the general impressions resulting from their vast experience. Adding to this whatever important enlightenment I could find by the perusal of the more recent current literature, I believe I have after all been able to come to some conclusions, and from them we may perhaps be able to outline some effective measures to diminish the sources of infection and to prevent the tuberculous infection from becoming tuberculous disease.

The answers to my first question, concerning the frequency of tuberculosis in general in childhood, would give an average of about 36 per cent.

Prof. Norman Bridge, Los Angeles, gave it as 22%
Prof. S. Solis Cohen, Philadelphia, gave it as 10%
Dr. Alfred F. Hess, New York, gave it as 38%
Prof. Godfrey R. Pisek, New York, gave it as 65%
Dr. Bertram H. Waters, New York, gave it as 26%
Hamburger and Monti, in *Amer. Jour. of Dis. of Child.*, Vol. 9, No. 6, June 1915, gave it as 59%
Veeder and Johnston, in same issue, gave it as 34%

From the interesting opinions given in answer to this inquiry I desire to quote the following:

Prof. Vincent Y. Bowditch, of

Boston, thinks latent tuberculosis is more frequent in children than has hitherto been supposed, only to become active in young or adult life.

Prof. Edward O. Otis, of Boston, writes: "I believe a large number of children have a tuberculous infection but comparatively few develop active clinical pulmonary tuberculosis before adolescence. Such I should say had been my experience."

Prof. Wm. P. Lucas, of San Francisco, feels strongly that it is time to differentiate between infection and disease in children. He believes that most city children become infected and in most cases produce definite immunity.

Dr. Alfred Meyer, New York, thinks the percentage higher than usually supposed in febrile cases without superficial evidence, such as lymphad and joint lesions, and that these cases are wrongly regarded as typhoids (even three or four attacks).

Prof. John L. Morse, Boston, says tuberculous infection is of course very common while tuberculous disease is relatively rare.

Newsholme, in *Lancet*, June 12, 1915, in the section referring to inaccurate diagnosis in children, quotes striking figures from Coates and Landouzy on the question of the prevalence of tuberculosis in children and also in relation to deaths. He states that "In children the term broncho-pneumonia not infrequently conceals acute tuberculosis, especially when the 'broncho-pneumonia' occurs after imperfect recovery from such diseases as whooping-cough and measles."

Concerning the various ages at which infection has most likely occurred, I received the following replies:

Dr. Alfred F. Hess, New York	Years. Under 1, 5%; 1 to 2, 33%; 2 to 3, 75%
Prof. John L. Morse, Boston	Infection and disease increase steadily with age.
Prof. Godfrey R. Pisek, New York	Year. 1st, 14%; 2d, 50%; 3d, 65%; 5th, 60%; 7 to 14th, 70%
Prof. Geo. M. Tuttle, St. Louis	Most frequent under 5 years of age.
Prof. J. A. Miller and Dr. I. O. Woodruff (*Jour. of A. M. A.*, March 27, 1909)	In children of tuberculous parents who live in close association with them, between 2 and 15 years, 51%
Prof. Hamburger of Vienna, in *Handbuch der Tub.*, Bd. V, 1915, gives the following table	Year. 1st, 1%; 2d, 9%; 3d to 4th, 27%; 5th to 6th, 51%; 7th to 10th, 71%; 11th to 14th, 94%
My own statistics reveal the following	Infection occurred apparently in children: Years. 1 to 5, 9%; 5 to 10, 34%; 11 to 15, 12%

Prof. Theodore Le Boutillier's remarks in answer to this question are likewise of intense interest. He says that he found that infection occurs with comparative infrequency during

early infancy when the child has been removed from the infected surroundings. He never found it to occur under these conditions. Where, however, the child remains in the infected surroundings, he thinks that, as a rule, these infants become actively tuberculous within the first year of life. It occurs most frequently during the second five years of life and then at puberty.

To the question which of the organs were most frequently involved, nearly all my correspondents united in the opinion that in children the lungs and lymph nodules were primarily and most frequently involved; secondly, bones; thirdly, intestines; fourthly, meninges.

I will quote from the remarks I received in answer to this question as follows:

Dr. E. R. Baldwin, of Saranac Lake, referred me to his article in Osler's System of Modern Medicine, last edition, in which he says: "In the majority a previous focus must be regarded as essential although infection through the tonsils or by way of the cribriform plate of the ethmoid may be possible. The most frequent lesion is in the lungs (50 per cent.), glandular tuberculosis probably comes next in frequency, and then joint, bone, genito-urinary, and pleural lesions."

Prof. Theo. Le Boutillier, of Philadelphia, thinks that the younger the child the more likely it is to be meningitis, next in frequency miliary tuberculosis; in older children, pulmonary, glandular and bone.

Prof. Wm. P. Lucas says that acute tuberculosis, in his experience, is nearly always found in infancy and rarely during childhood unless the infection is very virulent or quantitatively large. After five years of age the number of acute cases even of tuberculous meningitis or miliary tuberculosis diminish very rapidly. He has no absolute percentage from his own experience but thinks that practically all the infections are glandular, either peribronchial, peritoneal, or cervical and that the other forms of tuberculosis, bone, etc., are secondary to the glandular involvement.

Dr. Alfred Meyer has always been surprised at the comparative rarity of acute miliary and of meningitis considering the very favorable conditions for dissemination.

Prof. John L. Morse supposes that tubercular meningitis and miliary tuberculosis were always secondary to some previous infection.

As to the method of invasion, Prof. John Howland, of Baltimore, gave 95 per cent. through close personal contact with tuberculous individuals; Prof. Godfrey R. Pisek of New York 75 per cent.; Profs. Hermann M. Biggs and Henry D. Chapin of New York, William P. Lucas of San Francisco, and George M. Tuttle of St. Louis, concur in the opinion of Doctor Howland.

In our Health Department's clinics, Dr. Bertram H. Waters traced the majority of infection to the respiratory tract. My own statistics made me come to the same conclusion.

Somewhat divergent is the view expressed by Prof. Frank Billings of Chicago, who says that to him it seems that the most common source of the infection in the child and

adolescent is through the digestive apparatus, either from infected milk or other food substances or quite as frequently from actual contact with tuberculous adults and the contamination of hands, lips, etc., and with tubercle bacilli which gain entrance through the mucosa of the throat. He often wondered if this method of contact infection is not frequently present even in the adult rather than infection through infected air as is the commonly accepted mode. In other words, the last named mode of infection it seems to him is a very common one in both children and adults.

Prof. L. Emmett Holt, on the other hand, says that it has always been his belief that the dangers from tuberculous milk have been greatly exaggerated, certainly with infants and young children.

Prof. John L. Morse says that he has seen a considerable number of cases in which children with tuberculosis had taken the milk from tuberculous cows. He does not know, however, whether their infection was from the tuberculous milk or whether it was acquired in some other way.

As appertaining to this question we must add the following: Prof. William Charles White of Pittsburgh writes that in no way could he see that it is possible for us to trace the origin of infection from without although, in most of our general tuberculous cases, on which we have had autopsies, it is possible to trace infection from some glandular source of infection within the body.

Prof. Godfrey R. Pisek says, infections with human bacilli, in all probability, are the latent types; the bovine type of infection does not seem to remain latent and to develop in later life; perhaps this type even confers a certain immunity.

Prof. Beverley Robinson of New York says: "The pulmonary organs are those most frequently involved, as I believe, and that is also the impression of very many general practitioners."

My question concerning the frequency of prenatal infection received the least number of responses. Prof. Norman Bridge thought he had seen two cases; Prof. John Howland also two cases; Prof. A. Jacobi reported one case. Myself I believe to have observed two distinct cases of prenatal infection. Professor Pisek believes that only fifteen authentic cases have been reported. And yet, it seems to me this rarity is perhaps only apparent and the reason for it is to be found in the fact that autopsies in children are not made nearly as frequently as in adults. There have been a sufficient number of cases on record, however, to make it necessary to consider this direct bacillary transmission from the mother as one of the means of tuberculous infection, particularly when the mother has been acutely ill at the time of conception or during pregnancy.

This prenatal infection may also explain the occurrence of tuberculosis in early infancy, that is to say before the first year. Gärtner, of Jena ("Ueber die Erblichkeit der Tuberkulose," *Zeitschr. f. Hygiene u. Infektionskrankheiten*, Bd. XIII), who

made very extensive animal experiments in the endeavor to remove all doubts about this much disputed question, comes to the conclusion that the experiments with rabbits and guinea pigs disprove the possibility of the transmission of the tubercle bacillus from the father to the fœtus. When bacilli are very numerous in the semen, the mother becomes infected but never the offspring. On the other hand, the clinical reports and his own animal experiments have convinced him that tubercle bacilli are frequently transmitted from the mother to the child during the latter's prenatal existence.

Some time ago I had the honor of a conversation with Prof. Wm. H. Welch of Johns Hopkins Medical School on the subject and he, too, was of the opinion that a direct bacillary transmission, that is to say, prenatal infection, takes place much more frequently than is generally believed.

Prof. S. Solis Cohen says it is difficult to distinguish between prenatal infection, hereditary tendency, and infection early in life. He does not see a sufficient number of very young infants to be able to exclude the latter method in any instance.

Prof. A. Jacobi says that while direct heredity is rare, hereditary predisposition to tuberculosis is quite frequent, and is transmitted even by such parents as appear to be in fair health. It is evident that the newly-born cannot be safe with its consumptive mother.

As to the certainty that predisposition is frequently inherited from a tuberculous mother or a tuberculous father, an anæmic parent, or parents of feeble health or generally below par, there is of course not the slightest doubt. Any inherited systematic weakness of the child, which might be more properly called a physiological poverty, renders the child naturally more susceptible and less resistant to invasion of tuberculosis or other infectious diseases. When the mother is the tuberculous parent, this predisposition is all the more likely to be inherited because of the impregnation of the cells of the fœtus by the toxins of the tubercle bacilli, even if the latter have not been found in sufficient numbers in the cells to demonstrate direct bacillary transmission.

To the question at what period of life a tuberculous infection, contracted in infancy or childhood, was most likely to become active, I received the following answers:

Dr. W. Jarvis Barlow, Los Angeles, at 15 years.
Prof. Hermann M. Biggs, New York, between 6 and 25 years.
Prof. S. G. Bonney, Denver, between 18 and 25 years.
Prof. Vincent Y. Bowditch, Boston, at 15 years.
Prof. Norman Bridge, Los Angeles, between 15 and 18 years.
Dr. E. S. Bullock, Silver City, N. Mex., between 18 and 25 years.
Prof. Theo. Le Boutillier, Philadelphia, at 15 years.
Prof. Wm. P. Lucas, San Francisco, at 15 years.
Dr. Alfred Meyer, New York, at 10 years.
Dr. Charles L. Minor, Asheville, before 16 years.
Prof. Wm. P. Northrup, New York, between 3 and 12 years.
In my own experiences, I found that early infection had become active between 10 and 30 years.

The remarks on this question are significant and I will quote the following:

Dr. Alfred F. Hess, of New York, does not believe that the age is such an important factor as regards making an inactive process active, as is the general condition of the individual. Independent of age, if a person has measles, marked anæmia, or malnutrition from whatever cause, there is liability of the lighting up of the tuberculous focus.

Dr. G. W. Holden, of Denver, thinks a latent infection will not develop until such a time as the natural resistance has been broken down and vitality lowered, due to overwork or overplay, or a combination of both.

Prof. L. Emmet Holt, New York, thinks that age seems to have much less influence on this point than other conditions, such as season of year—winter and spring—and the development of intercurrent diseases such as measles, whooping-cough, influenza, and bronchitis.

Dr. David R. Lyman, of Wallingford, Conn., says that his own general impressions based chiefly upon the histories of his cases is that where an intelligent history is obtainable a very large percentage of our adult cases can be traced back to early youth or childhood, and that our future work must be devoted mainly to the prevention of tuberculosis in childhood.

Prof. Wm. Chas. White thinks that there is no period in life when tuberculosis may not be contracted.

Prof. Godfrey R. Pisek thinks the period of life in which latent tuberculosis is most likely to become active begins about the fifth year; this includes no observations after the fourteenth year of life.

To my last question, what was the age at which tuberculosis was found most frequently in the adolescent and the adult, I received the following answers:

	Years.
Dr. W. Jarvis Barlow, Los Angeles, gave the age at	20 to 29
Prof. Hermann M. Biggs, New York, gave the age at	16 to 25
Prof. Frank Billings, Chicago, gave the age at	15 to 25
Prof. Vincent Y. Bowditch, Boston, gave the age at	20 to 40
Dr. E. S. Bullock, Silver City, N. M., gave the age at	18 to 25
Dr. G. W. Holden, Denver, gave the age at	20 to 25
Prof. S. Solis Cohen, Philadelphia, gave the age at	18 to 22
Dr. Alfred Meyer, New York, gave the age at	15 to 40
Dr. Chas. L. Minor, Asheville, gave the age at	20 to 40
Prof. Edw. O. Otis, Boston, gave the age at	18 to 35
Dr. Bertram H. Waters, New York, gave the age at	25 to 40
Prof. Wm. Chas. White, Pittsburgh, gave the age at	20 to 40
In my own experience I found tuberculosis to be in evidence most frequently between	15 and 40

Of 1,000 private cases of adults of which I kept careful records, only 14.5 per cent. recalled an evident exposure to infection outside of their family circle during their adult existence as a possible cause of their disease. On the other hand, 33 per cent. stated that either father, mother, brother, or sister had died of tuberculosis or had been ill with the disease. In these cases we have reason to believe that infection occurred most likely during infancy or childhood.

The general impressions which were kindly given me by my correspondents

concerning my inquiry as to when a tuberculous infection became a tuberculous disease, or when the disease was first noticed in the adolescent or the adult, are to my mind fully as valuable as the statistical data.

Dr. Herbert M. King, physician-in-chief of one of our largest sanatoria where the vast majority of patients come from the well-to-do classes, writes as follows: "Speaking very generally, I think I share a widespread impression, amounting to almost conviction, that most of the cases of tuberculosis developing in adult life may be traced to infection received before adolescence."

Dr. Lawrence F. Flick, of Philadelphia, says: "From my experience in tuberculosis and from the studies I have made of the subject, I am led to believe that ordinary tuberculosis is implanted in early life and either remains dormant or grows very slowly until adult life is reached. My histories of cases taken as a whole would indicate that ordinary tuberculosis has existed for many years when a case comes under observation for the first time. The implantation undoubtedly most frequently takes place in the home through prolonged intimate contact with an open ulcerative case of tuberculosis in the intimacy of family life."

Prof. Wm. C. Hollopeter, of Philadelphia, writes: "I am a great believer in the early implantation of tuberculosis in children and believe that all children have it with very rare exceptions, the adult form is simply a recrudescence, or an expression due to lowered resistance of the individual."

Prof. John Howland, of Johns Hopkins, says: "We have had, in the dispensary and hospital, since I have been in Baltimore, 8,293 patients. Of these, 469 had tuberculosis recognizable in some form or other and we have not made the diagnosis of tuberculosis unless, in addition to the symptoms, tuberculin tests showed the presence of the disease. I have not included in this those patients, that, without other evidences of tuberculosis, gave positive von Pirquet reactions."

Dr. Martin F. Sloan, Superintendent of the Maryland State Hospital for Consumptives, writes: "I do not remember having seen one adult with a so-called acute invasion in whom a chronic lesion was not demonstrable in one of the apices. My limited experience leads me to believe that practically all cases of pulmonary tuberculosis in the adult are of endogenous origin. A carefully obtained history from an observing patient most frequently reveals one of a number of several manifestations of tubercle bacilli infection in early life, viz., nasal catarrh or middle ear trouble, tonsils and adenoids, 'white swelling,' malnutrition, 'winter colds,' enlarged cervical glands, at puberty, amenorrhœa, or irregular menstruation, nervousness, and poor development; and later, pleurisy, chronic bronchitis, 'typhoid pneumonia.' In other words, we find stepping stones, if you will, connecting an infection in early childhood with the pronounced case of consumption in adult life. This leads me to say, parenthetically, that I consider the critical periods of a woman's life, in so far as tuber-

culosis is concerned, are puberty, puerperium, and the climaterix; of a male's puberty, and about thirty to thirty-five years.

"Again, a careful history nearly always shows that at least one brother or sister, or maybe more, has had suspicious symptoms. I know several families that have been exterminated by consumption, though the members had been separated since childhood, all of which would seem to indicate an infection through a common carrier in early life, very likely a parent, nurse, or housemaid.

"On the other hand, I know of no employee about the sanatorium who has become a victim of the disease. After seven years' exposure I myself show no signs or symptoms of the disease. I must confess I am somewhat dubious of the frequency of adult infection, except in cases of the closest contact, such as is to be found in marital life."

Dr. Charles L. Minor, of Asheville, writes: "In my own experience I have found in the adolescent, the largest number of cases of tuberculosis appearing at about sixteen. In the adult the large majority have been between twenty and forty."

Prof. Wm. S. Thayer, of Baltimore, wrote: "As time has gone on I have been very much impressed in a purely general way with the feeling that most tuberculosis was acquired in childhood, but, alas, when it comes to a question of proof or even of strong evidence to support my feelings, I have it not. I have a very general feeling that glandular tuberculosis is especially common in childhood and I would be inclined to believe that most pulmonary tuberculosis was rather largely an autogenous infection from such early glandular foci, but, as I have said, I cannot feel that I am justified in expressing more than an impression with regard to the question. I shall be much interested to see your final conclusions."

Prof. John L. Morse, of Harvard Medical School, writes: "Both tuberculosis infection and tuberculosis disease are far more common among the poorer classes than among the well-to-do."

This statement that tuberculosis infection as well as tuberculosis disease is the lot of the child of the poor is borne out by the statistics furnished me, particularly those of Dr. Alfred F. Hess, who writes: "Among the children at the Infant Asylum who may be considered about the average of those living in the tenements, we have found that three-fourths of those under the age of five years give a positive von Pirquet test."

In these children, 75 per cent. means not infection but tuberculous disease, more or less active, for below the age of five the infection has rarely had a chance to become latent and the slightest additional pathological process, such as measles or anæmia, or simply malnutrition, is sufficient to produce a general and often fatal tuberculosis.

To make a brief summary of results from this little study, we would have to say that tuberculous disease in childhood, compared with tuberculous infection, is relatively rare (36 per cent.); that, on the other hand,

tuberculous infection is exceedingly frequent, generally speaking, and, according to exact statistics as well as general impressions given by men of vast experience, the majority of the cases in the adult had their origin in an infection during infancy or childhood.

The frequency of infection increases with the age of the child, and of course is also affected by the environment the child comes from.

	Percentage.	
	Lowest.	Highest.
Under 1 year,	1%	9%
From 1st to 3d year,	9%	50%
From 3d to 5th year,	27%	75%
From 6th to 10th year,	34%	75%
From 11th to 15th year,	(private) 12%	(hospital case) 94%

As to what organs are primarily most frequently involved, statistics and impressions give lungs and lymph nodules. Prenatal infection, while considered rare, is perhaps much more frequent than statistics show.

The age at which a tuberculous infection, contracted in infancy or childhood, becomes active is, according to the majority of my correspondents, at or shortly after fifteen years; next between eighteen and thirty years.

The ages at which tuberculosis was diagnosed and apparently contracted most frequently in later life, were given as most frequent between twenty and thirty-five years.

Nearly all the authorities consulted unite in the opinion that, in order to combat tuberculosis successfully in the young and the old, we must diminish the sources of infection in childhood.

And now, in conclusion, let me rapidly enumerate the measures which I hope and believe may tend to diminish this frequency of infection and when it does occur prevent the disease from developing.

(1) We must seek to amend the federal and state laws which make it a criminal offense for a duly licensed physician in good standing to give advice concerning the means of preventing conception. We must be allowed fearlessly and openly to instruct tuberculous parents how not to procreate a tuberculous race.

(2) All cases of open tuberculosis, particularly the pulmonary and laryngeal types, should be required by law to be reported to the health authorities who in turn should be authorized to send the patient directly, or through the attending physician, carefully worked out instructions to prevent infecting others.

(3) Cases which cannot be properly taken care of in the home, or when it is evident that they constitute centers of infection, should be transferred to sanatoria, special hospitals, or at least to special wards in general hospitals. Every community should have sufficient facilities to take care of such cases. The board of health of every community should have police power in order to be able to isolate such cases which wilfully disseminate bacilli by indiscriminate expectoration or by other unclean habits, thereby exposing other members of the family, particularly children, to contracting the disease.

(4) For the pregnant tuberculous woman there should be a maternity

sanatorium or a special ward in existing maternities where prolonged antituberculosis treatment can be effectually carried out and where mothers can receive such instructions as will guard their offspring from post-natal infection.

(5) Where there is the slightest suspicion of tuberculous infection of the infant by the mother, the child should have a healthy wet-nurse or should be bottle-fed. The preparation of the milk and bottles, testing the milk to judge of its sweetness and temperature, etc., should be attended to not by a tuberculous mother but by an intelligent and conscientious healthy person, unless the mother is scrupulously clean and knows how to take every proper precaution against infection. For infants whose mothers for one reason or another are unable or not intelligent enough to care properly for their tuberculous offspring, there should be established special preventoria. The need of such institutions has been very ably set forth in a recent contribution by Dr. Alfred F. Hess of New York, entitled "The Neglect to Provide for the Infant in the Antituberculosis Program."*

(6) Enterprises similar to the one inaugurated by my regretted teacher, the late Professor Grancher of Paris, for the purpose of providing medically supervised country homes for the tuberculous mothers and their children until they can safely return to city environments, should be helped by private philanthropy, or, better yet, by the aid of the municipality.

(7) All children under five years of age, be they of poor or rich parentage, should be subjected annually or even semi-annually, to the von Pirquet test, and all who react positively and have in addition symptoms and physical signs should be placed under proper treatment at home, in preventoria, or sanatoria.

(8) All children between five and fifteen years of age, particularly those attending public schools, should be subjected to a careful physical examination on entering as a pupil and an annual reëxamination thereafter, always accompanied by a von Pirquet test. Those reacting positively and showing physical signs, those evidently strongly predisposed to tuberculosis, anæmic, highly nervous or afflicted with cardiac disease, should, according to their condition, be placed in open-air classes, open-air schools, preventoria, seaside or inland sanatoria. This will probably mean that open-air schools must become the rule and the indoor class the exception which indeed would be a great blessing. It goes without saying that all physical defects, such as adenoids, enlarged tonsils, deviated septi, must be removed so that the child's upper respiratory tract may be as nearly perfect as possible. Defective hearing and eye-sight, as well as bad teeth, must, of course, also receive proper attention.

(9) Open-air instruction should be practised whenever feasible. Singing, recitation, geology, botany, etc., should be taught out-of-doors. Calisthenics, breathing exercises, and swimming lessons should constitute a part of the curriculum of every public and private

*Jour. Amer. Med. Ass'n, Dec. 19, 1914.

school. No public school should be without its swimming pool. A drill in swimming so as to know how to save one's own or perhaps other lives, should be as essential as fire drills in public schools. Wherever shower baths and swimming tanks (the former to be used prior to entering the latter) form a part of the public school equipment, pedagogues have observed a better morale and better work done by the pupils. The curriculum of our schools should be arranged so that the mental and intellectual training is not carried to the extent of becoming detrimental to the physical development and well-being of the children.

(10) The school authorities should have the right to investigate the home of any child attending public school when the teacher or school physician thinks that underfeeding, bad sanitary home environments, or child labor at home, are responsible for a poor physical condition of the pupil which might develop into tuberculosis.

(11) Child labor in factories, mines, canneries, stores, workshops, in the street or at home, must be done away with if we wish to raise a non-tuberculous race. Up to the age of fourteen every boy and girl should have the right and privilege to play and not be forced to work. When arriving at the age of puberty, the boy or girl should be in the best possible physical condition or else there is a great likelihood that a latent tuberculosis or inherited predisposition will develop into tuberculous disease. Playgrounds and parks should be in abundance in every civilized community. The roofs of schools and tenements should be converted into roof gardens when the ground is scarce and expensive, as for example in New York City.

(12) There should be an obligatory examination for tuberculosis and other serious diseases of every boy or girl prior to entering college, the store, the workshop, the office, mine, factory, or any occupation for his or her career in life. The physical and mental test at such a time should be used as a guide in the choice of trade or profession.

(13) There should be periodical examinations for tuberculosis of all employees in whatever sphere of activity—in office, factory, workshop, hotels, households, schools, municipal or federal departments, etc.

(14) For those weeded out as tuberculous or afflicted with other diseases which incapacitate them for their usual work under ordinary conditions, there should be agricultural and industrial colonies where these semi-invalids will have nevertheless an opportunity to earn a livelihood. There also the graduates from sanatoria should be sent for an opportunity to regain strength and vigor, to make their cure more lasting, and above all to learn again to earn their living.

(15) There should be state insurance or obligatory private insurance against accident, old age, and diseases including tuberculosis for all earning less than $1,000 per annum, so that those fearing temporary or total loss of earning capacity will not be afraid to seek proper treatment in tuberculosis institutions.

(16) Although the investigations, the replies from eminent authorities,

and the literature consulted seem to show that the bovine type of the bacillus of tuberculosis at a maximum estimation is not responsible for more than 10 per cent. of tuberculosis in childhood, we must not allow ourselves to lessen our efforts to combat the disease in animals. We should not have individual and widely differing state laws but instead uniform bovine laws enforced by federal authorities in all states of the Union alike. Only thus will we be able to combat the source of infection for human beings which comes from the bovine race.

(17) With all this there must be a continued propaganda for the education of the masses concerning the prevention of tuberculosis, alcoholism, and other social diseases; for the improvement of housing conditions including the supervision and better sanitation of city and country schools, of lodging houses, boarding houses, factories, workshops, stores, offices, asylums, prisons, and reformatories; for the prevention of injurious overwork; for healthful recreation of the masses in city and country; for the return to the soil from our overcrowded cities; and above all, for a living wage for all who labor honestly and efficiently and a rational and speedy solution of the problem of unemployment.

I grant that this is an elaborate and extensive program, but if you take into consideration the financial sacrifices this nation is annually making to combat tuberculosis, you will perhaps see the justification of it. In spite of all our efforts, we are still losing about 200,000 people annually from tuberculosis in the United States, of which, I venture to say, 50,000 are children. Estimating the average duration of life of these 50,000 children at about seven and one-half years, and figuring the cost to parents and the community for each life as only $200 per annum, the financial loss thus represented is $75,000,000. These children have died before they have been able to give any return to their parents and the community. What a useless sacrifice of life and of money! How much needless sorrow and heartaches caused to parents!

Besides all this, many a tuberculous mother has had her life shortened because she bore one of these children. According to the report of the Commissioner of Education, there are at this time about 20,000,000 children attending public schools in the United States. Placing the proportion of tuberculosis among them as low as only 3 per cent., would make 600,000 children afflicted with tuberculosis who are at this time in urgent need of open-air instruction or sanatorium treatment. According to available statistics, we can at present provide instruction in open-air classes for about 2,000 tuberculous children. The anæmic, the nervous, and the children suffering from cardiac diseases, who are in equally great need of outdoor instruction, are not included in the 3 per cent.

The 150,000 adults who die annually of tuberculosis have on the average been ill and incapacitated for work for at least two years, and figuring their cost to the commonwealth (either to municipality or individual family) at

only $1,000 per year, would mean $300,000,000 uselessly spent in caring for people afflicted with a disease that might have been prevented or cured. Of these 150,000 adults, a large number have been married and in many instances leave either widow or orphans depending upon public support. The annual maintenance of these widows and orphans must, of course, also run into the millions. We have thus an annual expenditure of well-nigh $400,000,000. Yet this by no means represents all the actual loss to the community from tuberculosis. Our social economists tell us that between the ages of sixteen and forty-five every adult life with an average earning capacity represents an asset of $5,000 to the community. Now, as two thirds of all deaths from tuberculosis in adults occur between these ages, we have an additional loss of $500,000,000. Thus, the actual direct and indirect loss caused by deaths from tuberculosis in the United States amounts annually to something like $900,000,000, and this amount we spend on a preventable and curable disease!

We must also bear in mind the fact that we have at least eight times 150,000 tuberculous adults, for it is well known that for every individual who dies of tuberculosis there are eight living with the disease, still up and about, and the majority of them with an opportunity of spreading infection. Besides these, there are 400,000 to 600,000 tuberculous children. By reason of lack of open-air schools, preventoria, sanatoria, special hospitals, and horticultural, agricultural and industrial colonies, the vast majority of nearly 2,000,000 tuberculous individuals continue the chain of infection and keep up our fearful morbidity and mortality at an expense of $900,000,000 per annum.

To carry out the program I suggest will not cost us $900,000,000 a year. If at first it should even approach this vast sum, within a very few years the expenditure as well as the morbidity and mortality from tuberculosis will be reduced to a minimum.

This little study, inadequate and doubtlessly defective in some respects, has nevertheless convinced me that there never will be a solution of the tuberculosis problem if we do not attack tuberculosis in infancy and childhood. This must be done first by diminishing the sources of infection; secondly, by curing the curable.

While I am willing to grant that an early and benign infection may be an immunizing factor, we know that it is neither universal, permanent nor complete, hence we must spare no efforts to diminish all sources of infection. It is the safer way. The measures outlined will prevent a benign infection from becoming disease and render the young child or adolescent more immune to future infections by increasing the natural resistance. The most expedient way to carry out the suggested program would of course be by a Federal Commission of Tuberculosis which I have ventured to suggest a number of times, but the need of which has been set forth recently and most convincingly by Lee K. Frankel, Ph.D., sixth vice-president of the Metropolitan Life Insurance Company,

in a paper entitled "A Plea for a Federal Commission on Tuberculosis." This paper was read before the Mississippi Valley Conference on Tuberculosis, September 30, 1915. This conference, as well as the South Atlantic, New England, and North Atlantic Tuberculosis Conferences, has unanimously adopted resolutions endorsing such a commission. The child of today is the man of tomorrow. If we wish to have a non-tuberculous race, a nation stronger physically, mentally, and morally than we have ever had before, the solution of the tuberculosis problem will bring us nearer this goal.

Appendix.

Since the above paper was sent to the American Journal of Public Health for publication, many other answers to letters of inquiries have come in and important events have transpired which made a revision with some changes and additions necessary and advisable in order to bring this contribution up to date. Among the events which happened was a remarkable address on The Control of Tuberculosis by Doctor Heiser at the Second Annual North Atlantic and New York State Conference on Tuberculosis which was held in Albany on November 4, 1915, and to which it was my privilege to listen.

Dr. Victor C. Heiser, formerly Chief Health Officer of the Philippine Islands, now the Director for the East of the International Health Commission of the Rockefeller Foundation, who had just returned from a visit to Australia, told us that in Victoria, Australia, tuberculosis was virtually stamped out and that this had been done by the simple method of having every tuberculous case reported and every individual afflicted with tuberculosis treated. If the authorities had convinced themselves that the patient did not constitute a center of infection in his home and had a reasonable chance of becoming cured (that is, if he had an outdoor sleeping porch and obeyed all prophylactic and curative measures) he was allowed to remain there. If, after investigation, the sanitary officers become convinced that a patient cannot be treated safely at home, he is compelled to enter an institution. If the patient is the bread winner of the family and of no means, and his sick and invalidity insurance is insufficient, the municipality assumes the responsibility of taking care of the family until the breadwinner is restored to his earning capacity. Children, when tuberculous, are being taken care of in the same way as the adults.

In our large congested American cities, as for example in New York, with our heterogeneous population, our social conditions and economic laws so vastly different from Australia, it may seem ludicrous to expect that anything like their method could be inaugurated. Yet I believe that by a united effort on the part of our statesmen to bring about insurance against disease, including tuberculosis, by the enforcement of antituberculosis laws and regulations in a strict but humane way such as is outlined in the above article, and lastly, by the aid of philanthropists to improve

the general housing and working conditions of the masses, the tuberculosis problem might be solved in the United States as well as in Australia, and in less time than might be thought possible. It needs a wise philanthropy, a just government, unselfish and enlightened statesmen, practical and expedient municipal laws, well-trained sanitarians and physicians, and an intelligent people to gain the victory over the great white plague.

The concluding sentence of Doctor Heiser's address may be well worth repeating here: "If it is possible for Australia to effectually combat tuberculosis, why should it not be possible for the United States to do so?"

The Metropolitan Life Insurance Company, which has already done so much toward educating the people in public health measures, and particularly in the prevention of tuberculosis, by its visiting nurses, by distributing educational leaflets to its policyholders and the public at large, and which has also shown its great interest in the cure of the tuberculous by establishing an ideal sanatorium at Mount MacGregor for its tuberculous employees, is evidently of the same opinion as Doctor Heiser. This great company is willing to give the method a trial, and has generously donated $100,000 so as to imitate the Australian experiment in the United States. This sum was offered officially to the National Association for the Study and Prevention of Tuberculosis at its Meeting in Washington, May 11 of this year, 1916, and gratefully accepted for the purpose designated by the directors of the Metropolitan Life Insurance Company.

It is planned to select a town or city of about 5,000 inhabitants, probably in New York or Massachusetts, and to apply there all of the knowledge on the treatment and prevention of tuberculosis available, with a view to the ultimate eradication of the disease. The following conditions will govern the selection of a city:

(1) The community must be one approximately 5,000 population.

(2) The composition of the population must be of a mixed character, racially, industrially, and socially.

(3) It should preferably not be a one-industry town, but should have several industries.

(4) The community must *welcome* the experiment and must promise cooperation of physicians, health boards, mayor, councils, and other civic, social, and industrial groups.

(5) It is the purpose of the experiment to attempt to show the community selected how, with proper direction, it can stamp out tuberculosis from its midst. To this end, the city or town should have access to certain agencies and institutions which can and will coöperate in the work. Such agencies as a county or city tuberculosis hospital, a tuberculosis clinic, open-air schools, visiting nurses, organized relief-giving agencies, etc., will be invaluable to the success of the community experiment.

The following are the resolutions which were adopted by the Association in accepting the $100,000 gift:

"The National Association for the Study and Prevention of Tuberculosis

expresses its hearty appreciation of the generous proposition of the Metropolitan Life Insurance Company to contribute $100,000 for conducting a community experiment in the control of tuberculosis. In undertaking this trust the Association hopes that the results of the experiment may be commensurate with the desires which inspired the offer."

PLAGUE.

It is a remarkable fact, confirmed by many observations, that many physicians who have devoted considerable labor to the study of a particular disease have themselves died of that disease. One of the most interesting examples is that of John Daniel Major, born August 16, 1634, in Breslau, a physician and naturalist of no mean ability. Bitten early by the wanderlust, he studied at Wittenburg, took courses at many of the schools in Germany, and finally went to Italy where he received the degree of doctor of medicine at Padua in 1660. Returning to his own country, he resided for a short time in Silesia, and in 1661 married at Wittenburg, Margaret Dorothy, a daughter of the celebrated Sennert. The following year, his young wife was stricken with plague and died after an illness of eight days. Distracted by his loss, Major wandered up and down Europe studying plague wherever he found it in the hope that he might discover a cure for the disease which had bereaved him. Spain, Germany, France and Russia were visited by him. He settled in 1665 in Kiel, where he was made professor of botany and the director of the botanical gardens. He made frequent voyages, however, always in quest of the remedy for plague. Finally in 1693, he was called to Stockholm to treat the queen of Charles the Eleventh, then ill with plague. But before he could render her any service, he contracted the disease and died on the third of August.

The bubonic plague of today is identical with the black death of the Middle Ages. Primarily a disease of rodents caused by a short dumb-bell shaped microscopic vegetable, the pest bacillus, it occurs in man in three forms; the pneumonic, which has a death-rate of almost 100 per cent.; the septicaemic, which is nearly as fatal, and the bubonic in which even with the most modern methods of treatment the mortality is about 50 per cent. It is a disease of commerce, spreading around the globe in the body of the ship-borne rat. It is estimated that every case of human plague costs the municipality in which it occurs at least $7,500. This does not take into account the enormous loss due to disastrous quarantines and the commercial paralysis which the fear of the disease so frequently produces.

The disease is now treated by a serum discovered through the genius of Yersin. This is used in much the same way as is diphtheria antitoxin.

Plague is transferred from the sick rodent to the well man by fleas. The sick rat has enormous numbers of plague bacilli in its blood. The blood is taken by the flea which, leaving the sick rat, seeks refuge and sustenance on the body of a human being to whom it transfers the infection.

Since plague is a disease of rodents and since it is carried from sick rodents to well men by rodent fleas, safety from the disease lies in the exclusion of rodents, not only exclusion from the habitation of man but also from the ports and cities of the world. Those who dwell in rat-proof surroundings take no plague. Not only should man dwell in ratproof surroundings, but he should also live in ratfree surroundings. The day is past when the rodent served a useful purpose as the unpaid city scavenger. Rats will not come where there is no food for them. Municipal cleanliness may be regarded as a partial insurance against plague. The prayer that no plague come nigh our dwelling is best answered, however, by rat-proofing the habitations of man. Modern sanitary science has evolved a simple and efficient weapon against the pestilence which walketh in darkness and striketh at noonday, and the United States Public Health Service has put this knowledge into practical operation and thus speedily eradicated plague wherever it has appeared in the United States.